



# CrIS observations of atmospheric composition in fire plumes over the Western US in summertime

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1. Jet Propulsion Laboratory, California Institute of Technology, 2. BAERI/NASA Ames, 3. Colorado State University, 4. National Center for Atmospheric Research, 5. Atmospheric and Environmental Research,

## Acknowledgements:

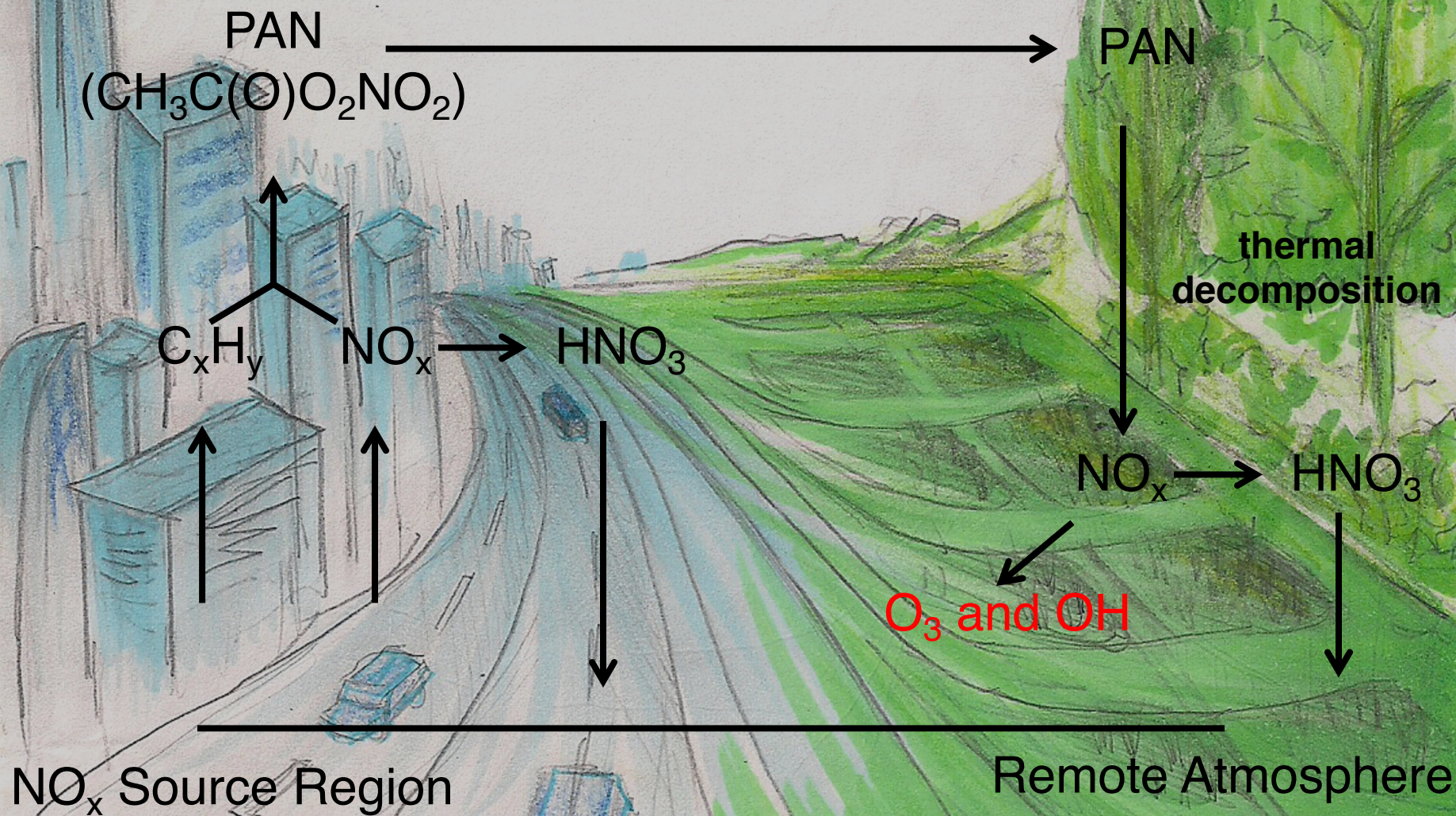
JPL: Dejian Fu, Ming Luo, MUSES algorithm team  
NASA Sounder Science Team  
Sentinel Hub website

**AIRS Science Team Meeting, Pasadena, April 2019**

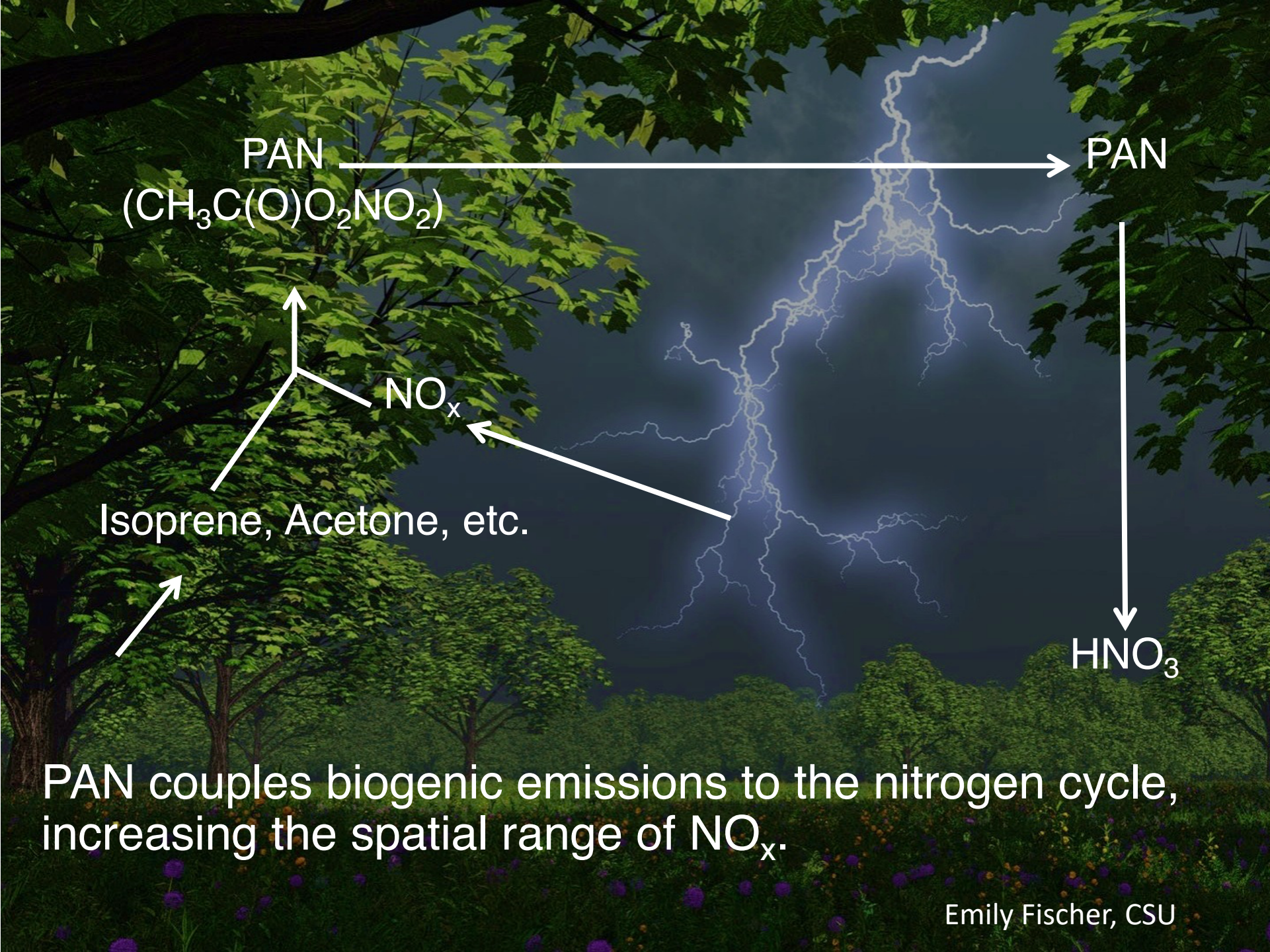
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PAN is the route for  $\text{NO}_x$  to reach the remote troposphere.









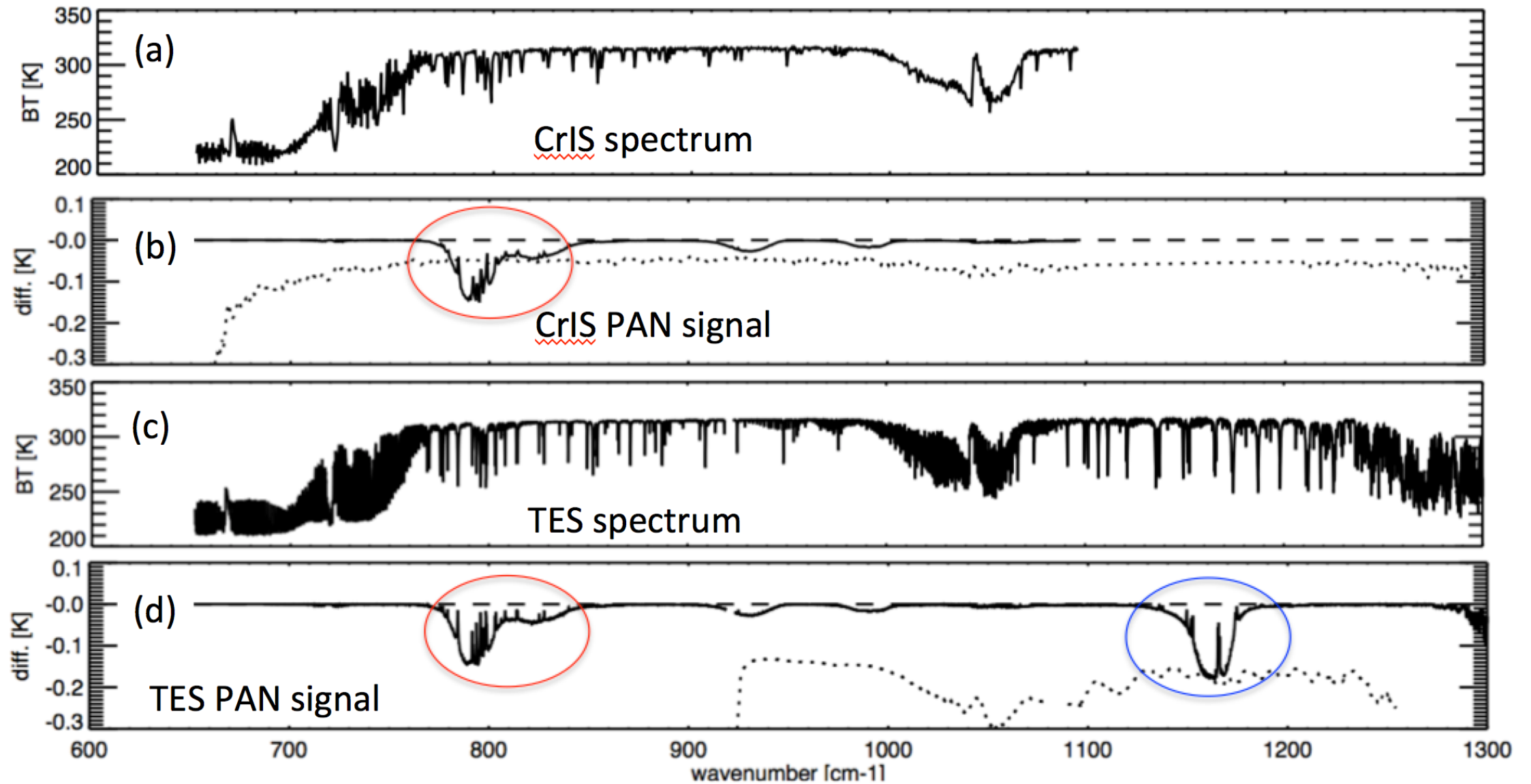
PAN extends the air quality impacts of fires.



Emily Fischer, CSU

Photos of High Park Fire from CNN

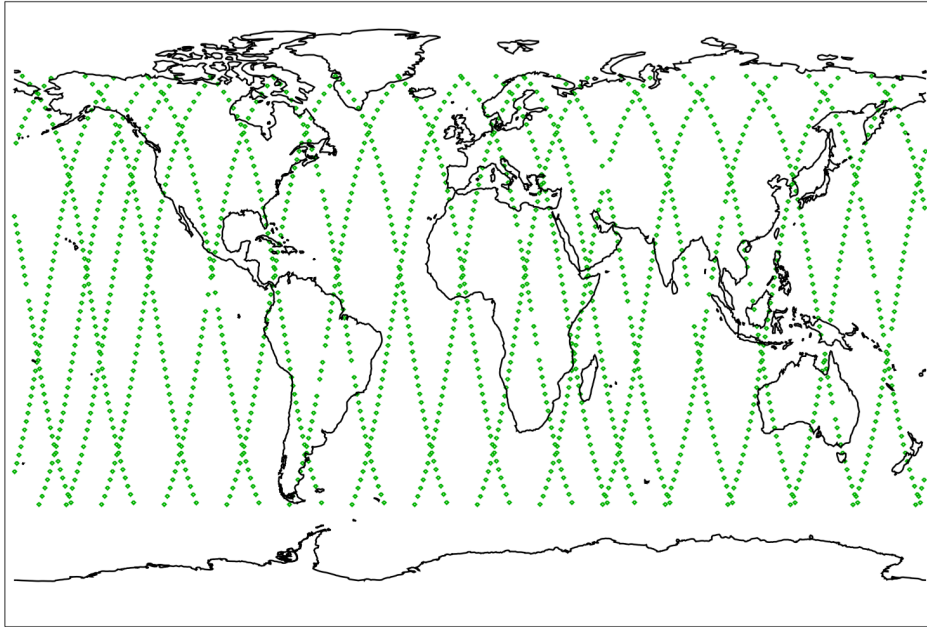




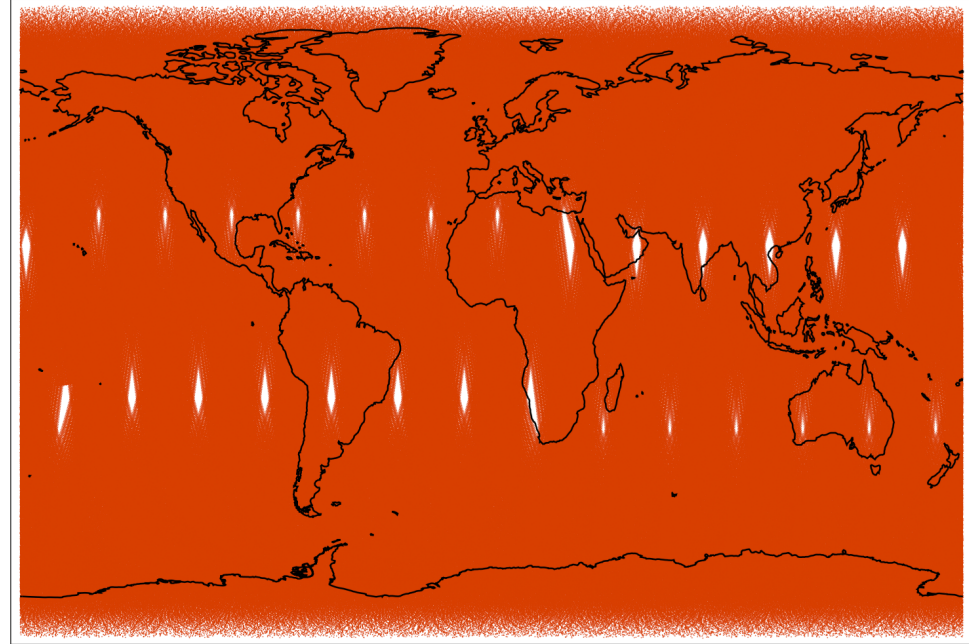
TES PAN retrievals are now available for the full TES record as part of the TES V7 Level 2 release.



# TES and CrIS coverage



TES coverage for 8<sup>th</sup> November 2017



SNPP-CrIS coverage for 8<sup>th</sup> November 2017





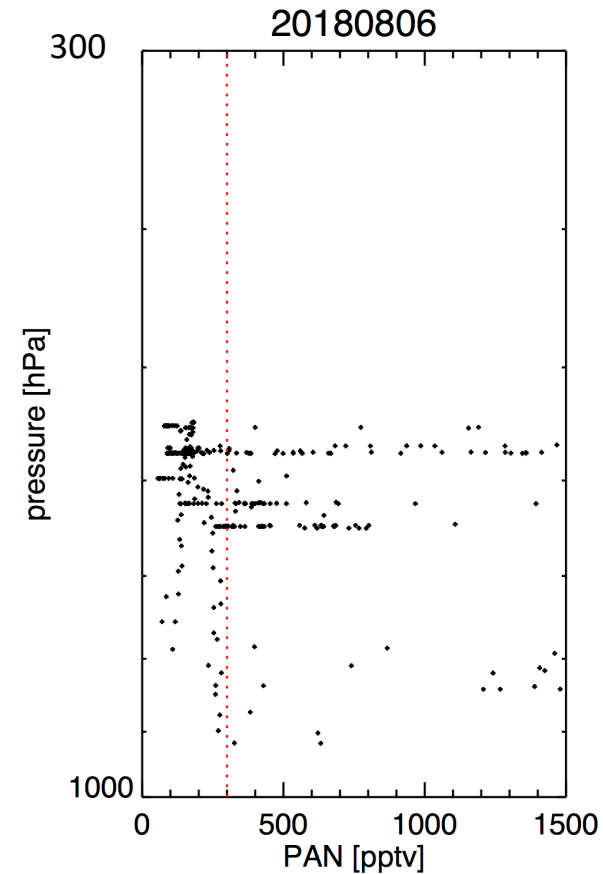
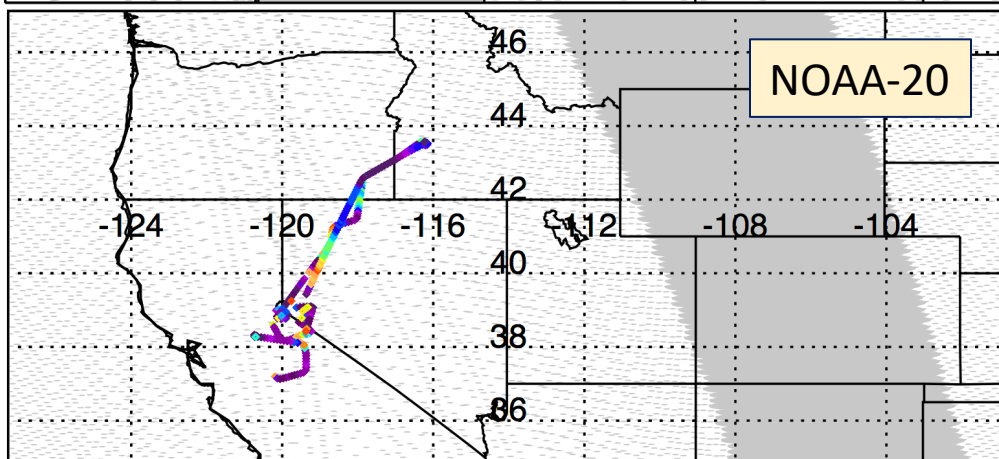
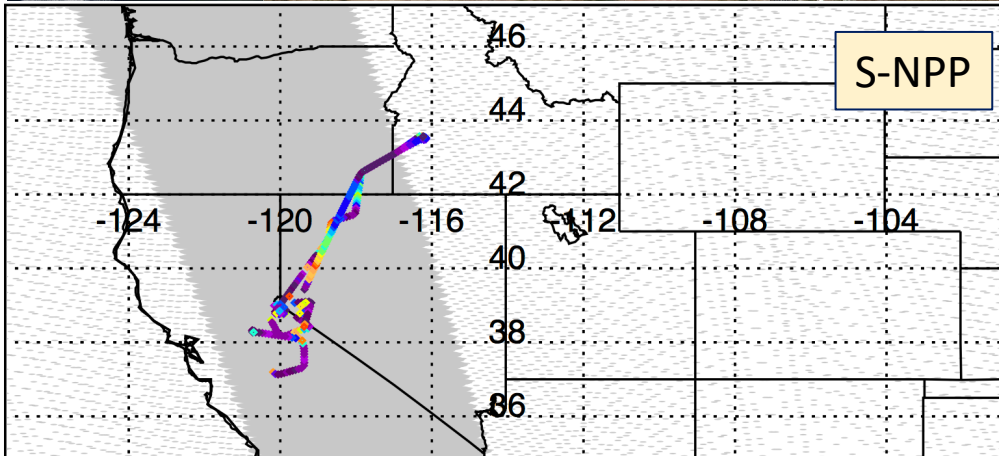
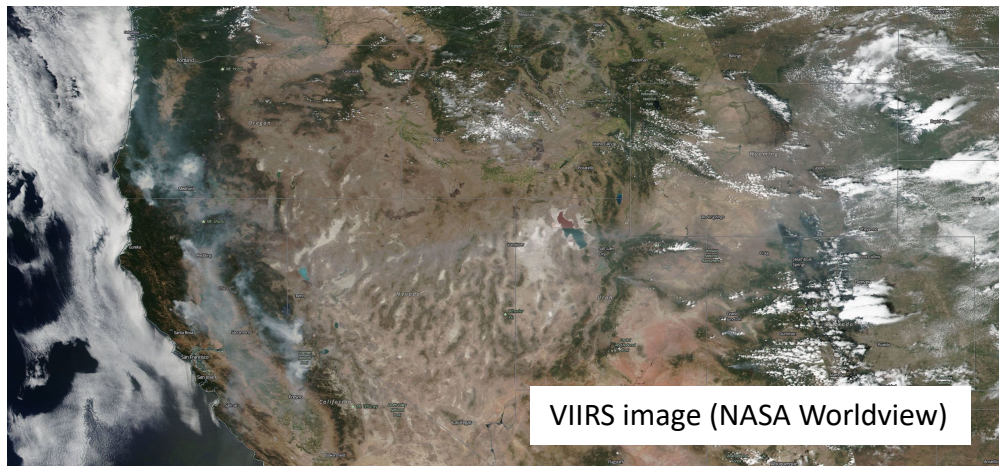
[https://www.eol.ucar.edu/field\\_projects/we-can](https://www.eol.ucar.edu/field_projects/we-can)



Image credit: <https://www.boiseweekly.com/>

WE-CAN aircraft campaign: July 22<sup>nd</sup> to September 14<sup>th</sup> 2018

## Example WE-CAN flight day: 6<sup>th</sup> August 2018



Points show aircraft  
PAN measurements

Red line: 300 pptv

Western US is relatively cloud-free on  
this and other WE-CAN flight days.  
(Eastern area of this box is cloudy for this day.)

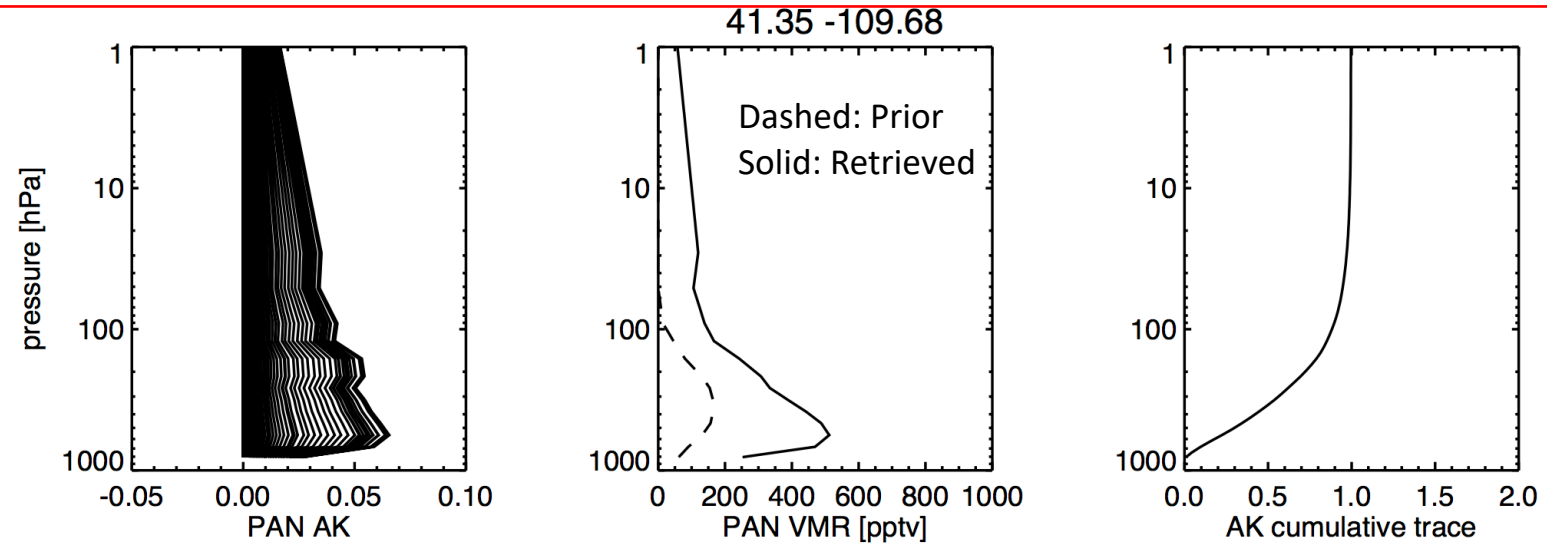


# MUSES single footprint retrievals

- **Optimal estimation retrieval algorithm**
  - MUSES (Multi-species, multi-spectrum, multi-satellite)
  - Single footprint (FOV) retrievals from L1B radiances
- **Forward model**
  - OSS (Optimal Spectral Sampling) from AER
  - Trained on LBLRTM v12.4 with tes\_v\_3.0 line file
- **Sequential retrieval strategy**
  - **PAN retrieval** step follows other steps to fit for surface temperature, surface emissivity, cloud parameters, atmospheric temperature, H<sub>2</sub>O, CO<sub>2</sub>, O<sub>3</sub>
  - **MUSES also allows retrievals of other trace gases (e.g. CO)**
- **Vertical sensitivity**
  - CrIS (and TES) sensitive mainly to **PAN** variations in the mid-upper troposphere
  - Can show sensitivity to lower troposphere under certain conditions
  - DOFS ~1.0

# Vertical sensitivity: Example fire plume case

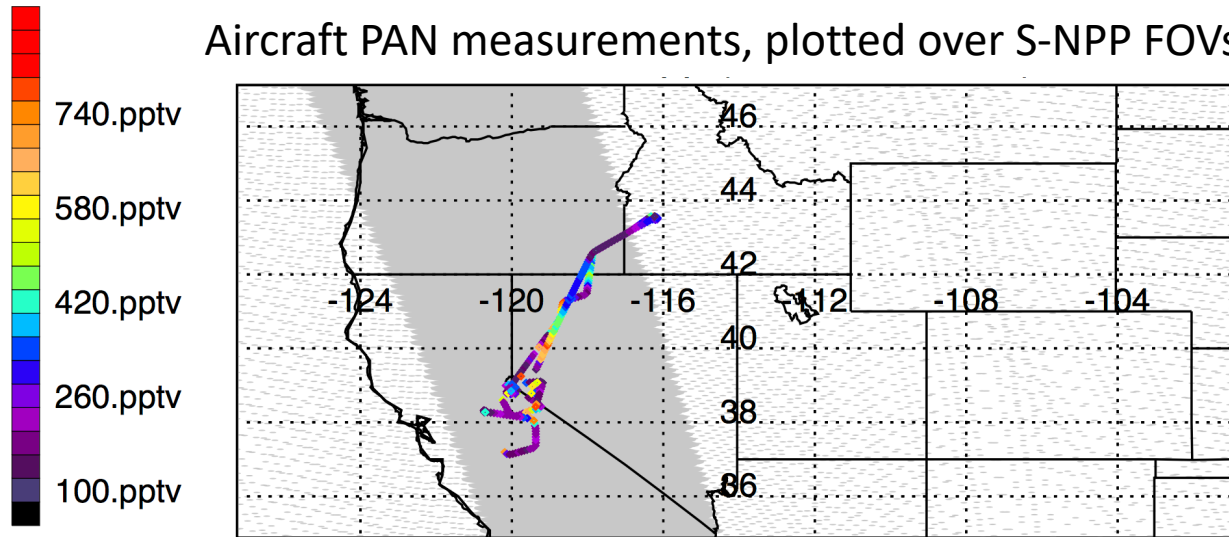
PAN



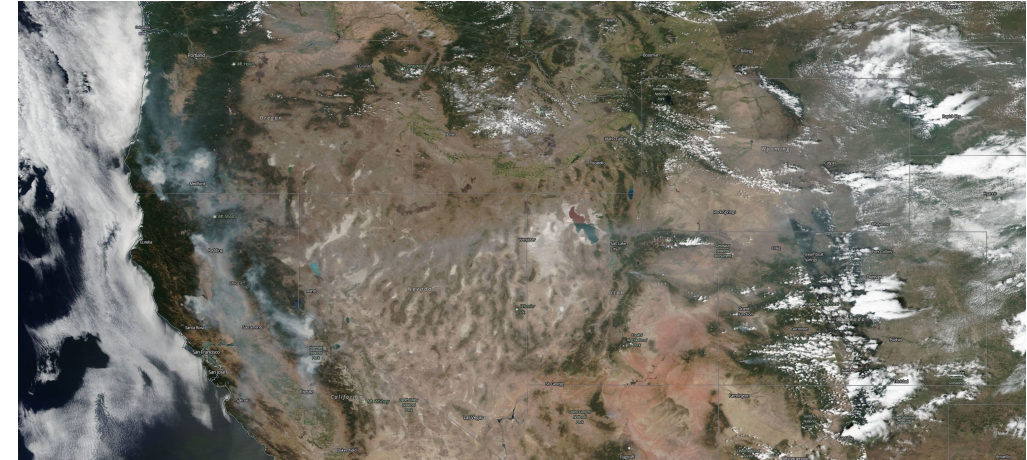


# Example day: 20180806

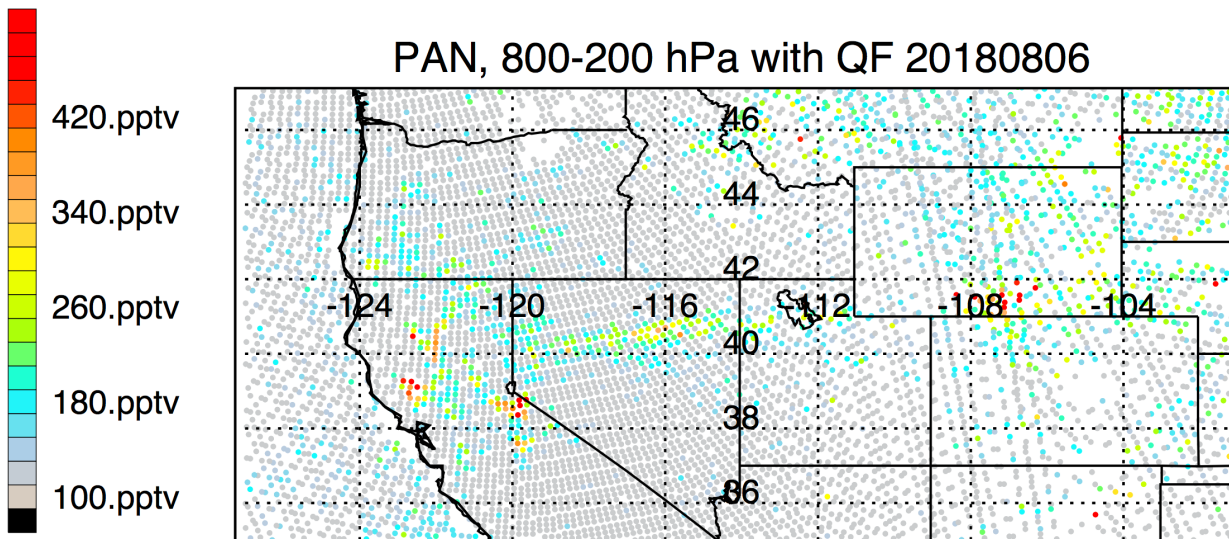
Aircraft PAN measurements, plotted over S-NPP FOVs



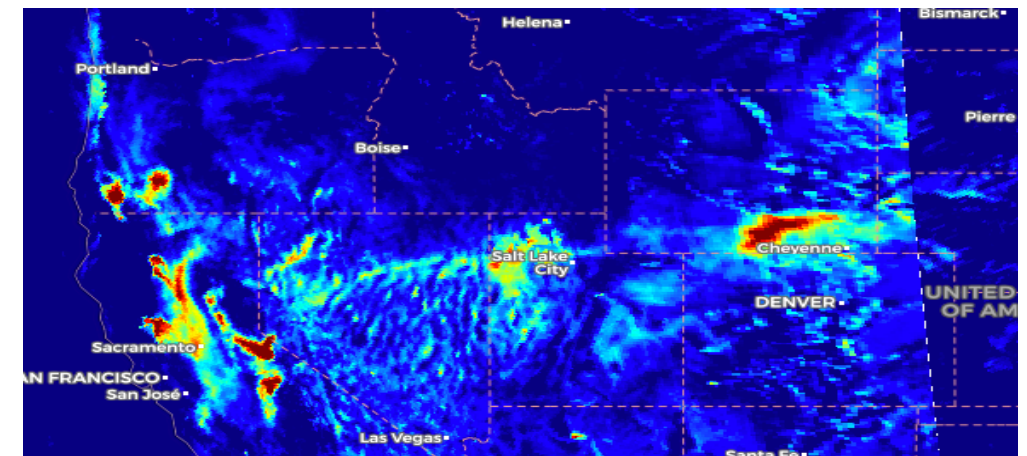
VIIRS image (NASA Worldview)



PAN, 800-200 hPa with QF 20180806



TROPOMI: Flying in constellation with S-NPP



MUSES CrIS PAN retrievals (vertical averages)

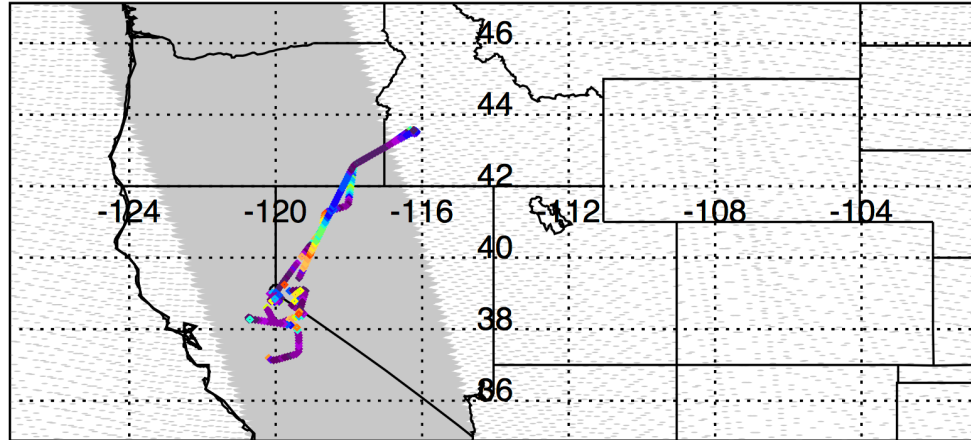
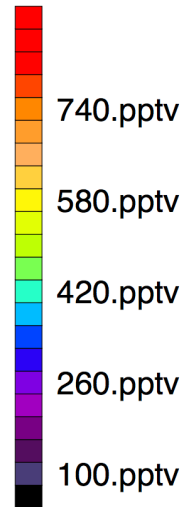
TROPOMI aerosol index (Sentinel Hub website)

Thanks to Bryan Baum for pointing out existence of this product!

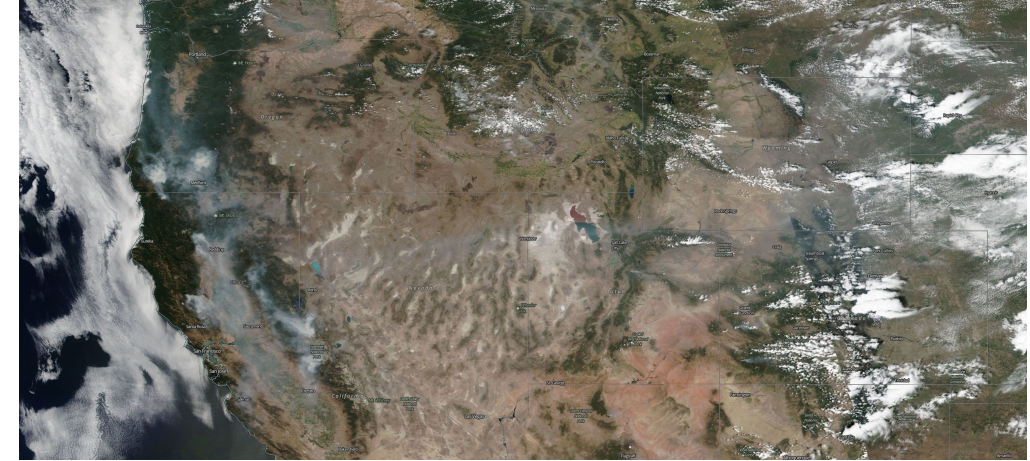


# Example day: 20180806

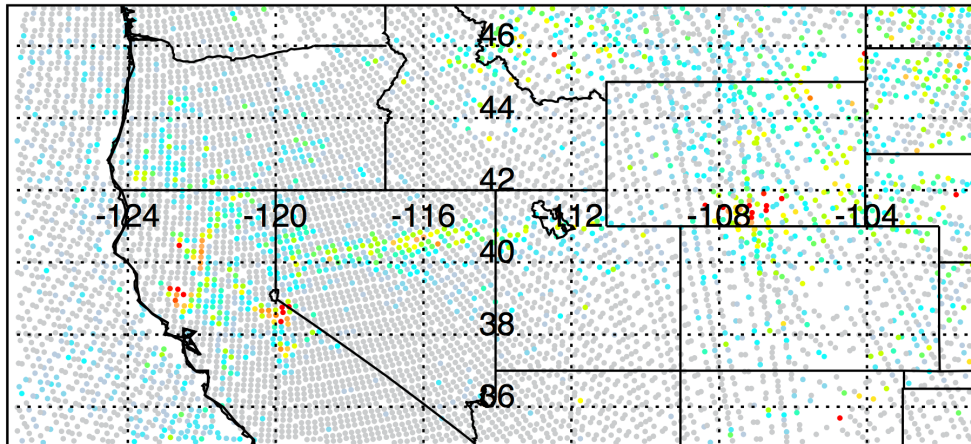
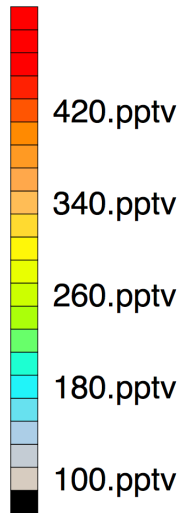
Aircraft PAN measurements, plotted over S-NPP FOVs



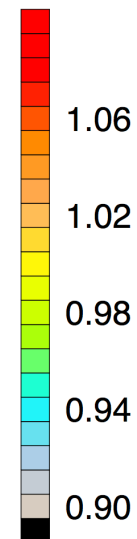
VIIRS image (NASA Worldview)



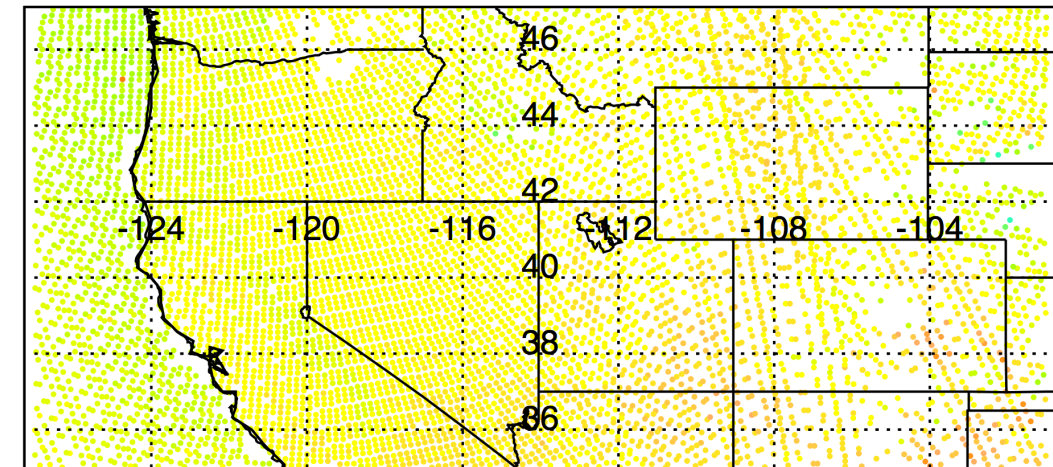
PAN, 800-200 hPa with QF 20180806



CrIS PAN retrievals (vertical averages)



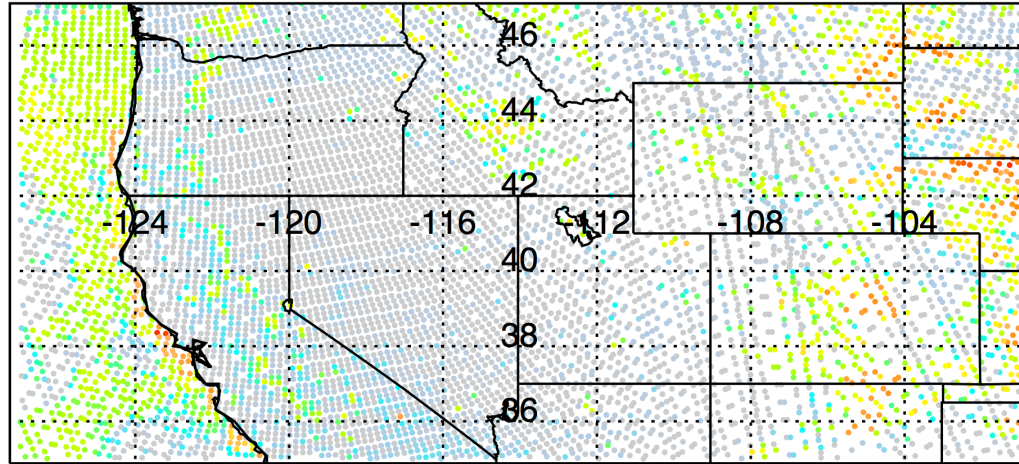
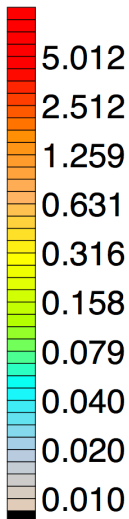
PAN DOF 20180806



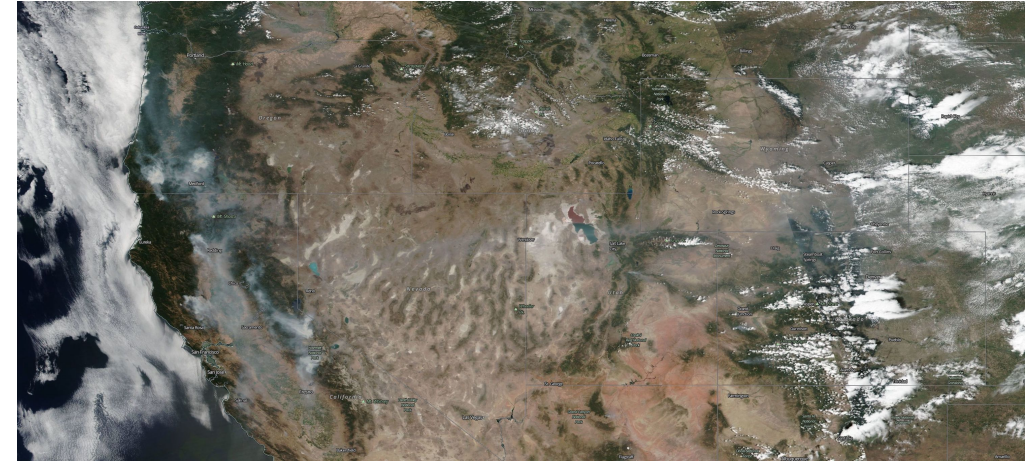


# Example day: 20180806

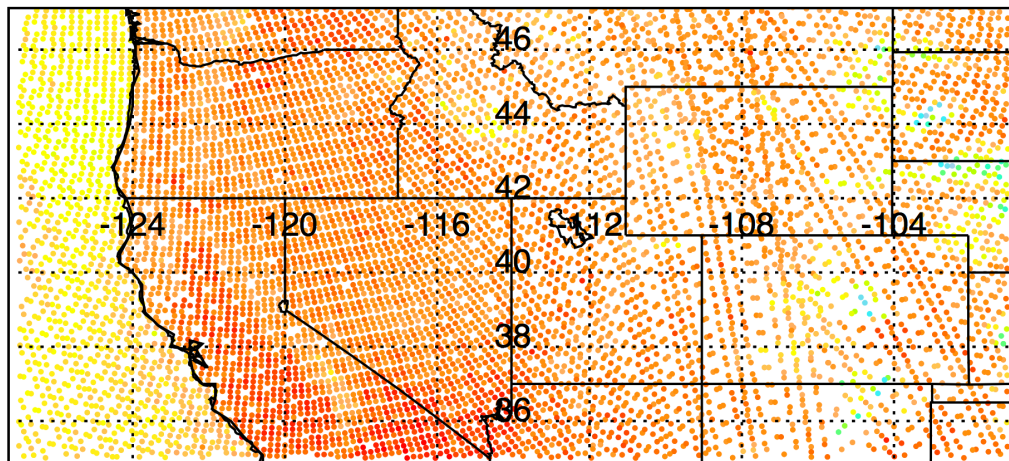
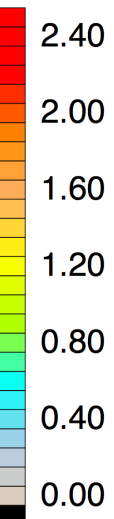
MUSES retrieved cloud optical depth from S-NPP CrIS



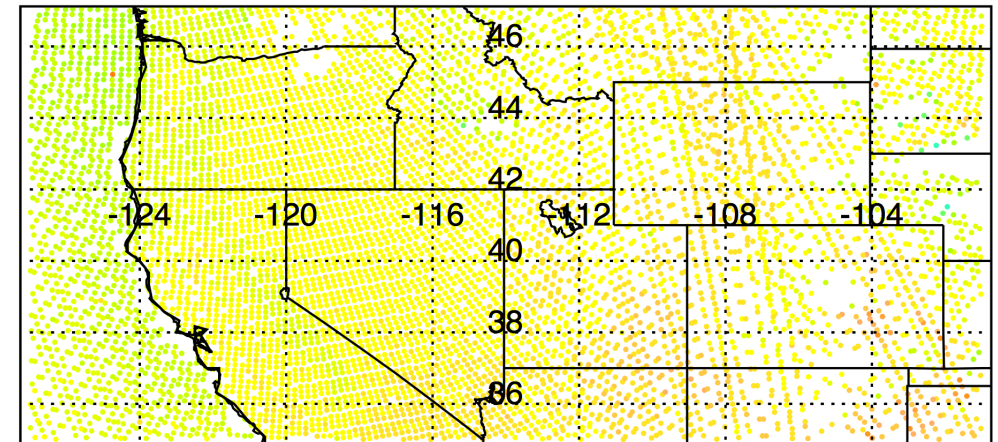
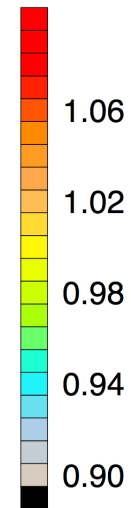
VIIRS image (NASA Worldview)



CO DOF, 20180806



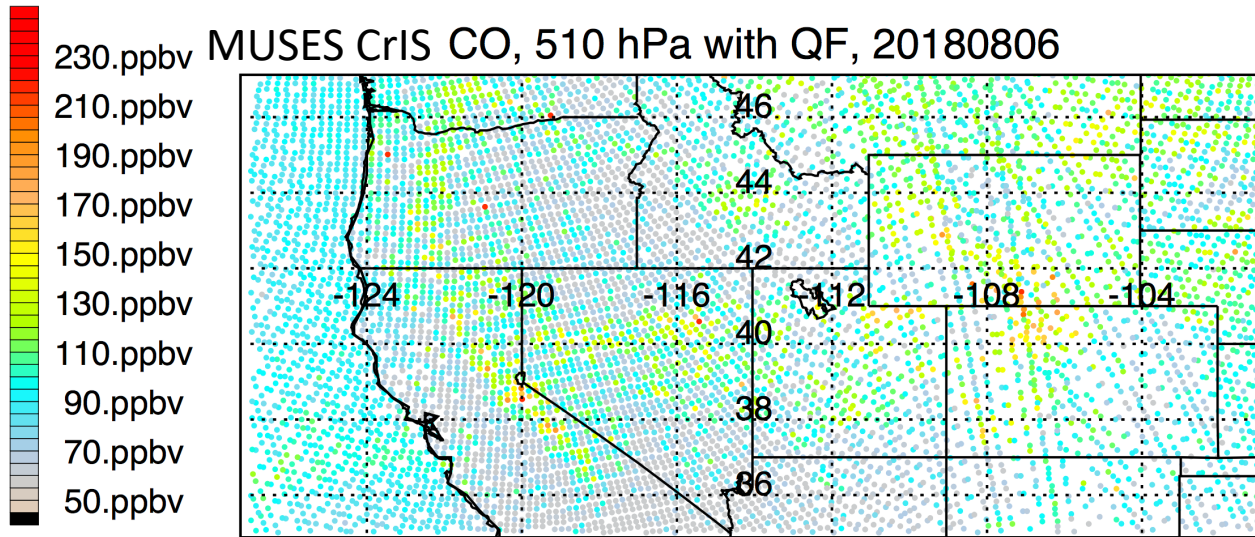
PAN DOF 20180806



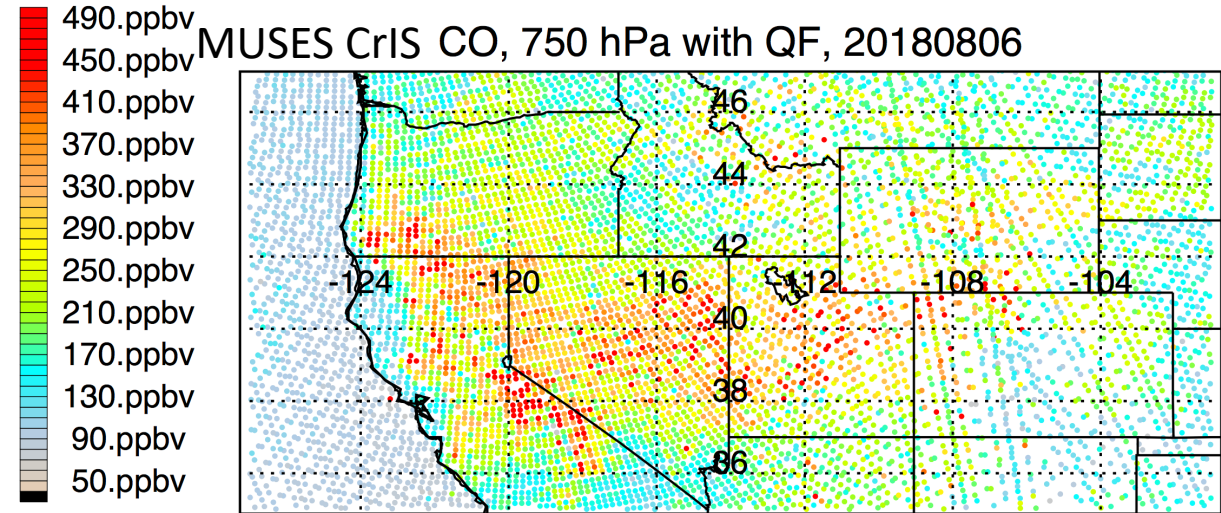


# 20180806: PAN and CO

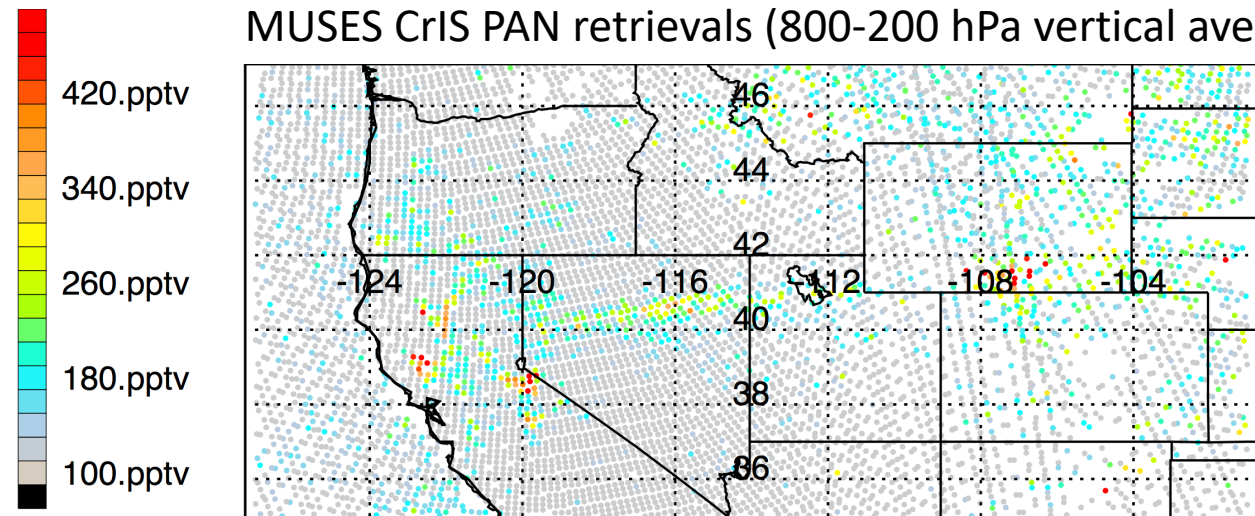
MUSES CrIS CO, 510 hPa with QF, 20180806



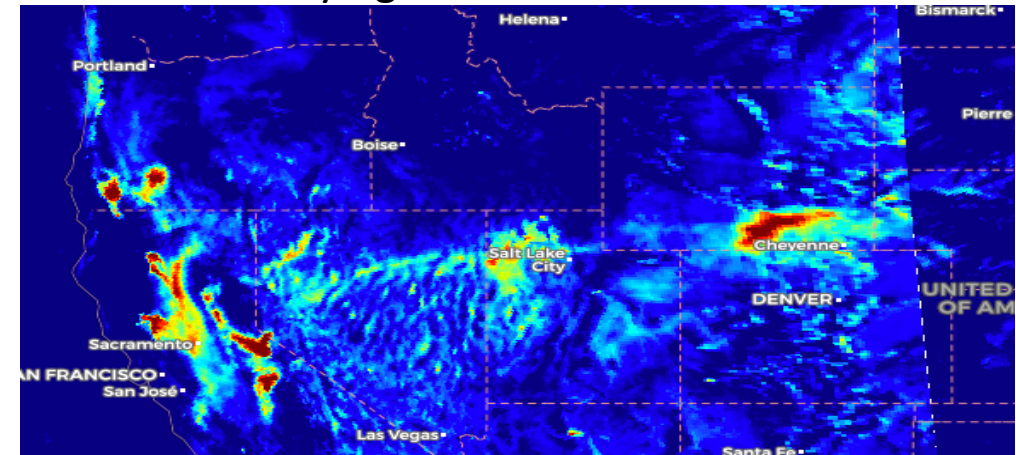
MUSES CrIS CO, 750 hPa with QF, 20180806



MUSES CrIS PAN retrievals (800-200 hPa vertical average)



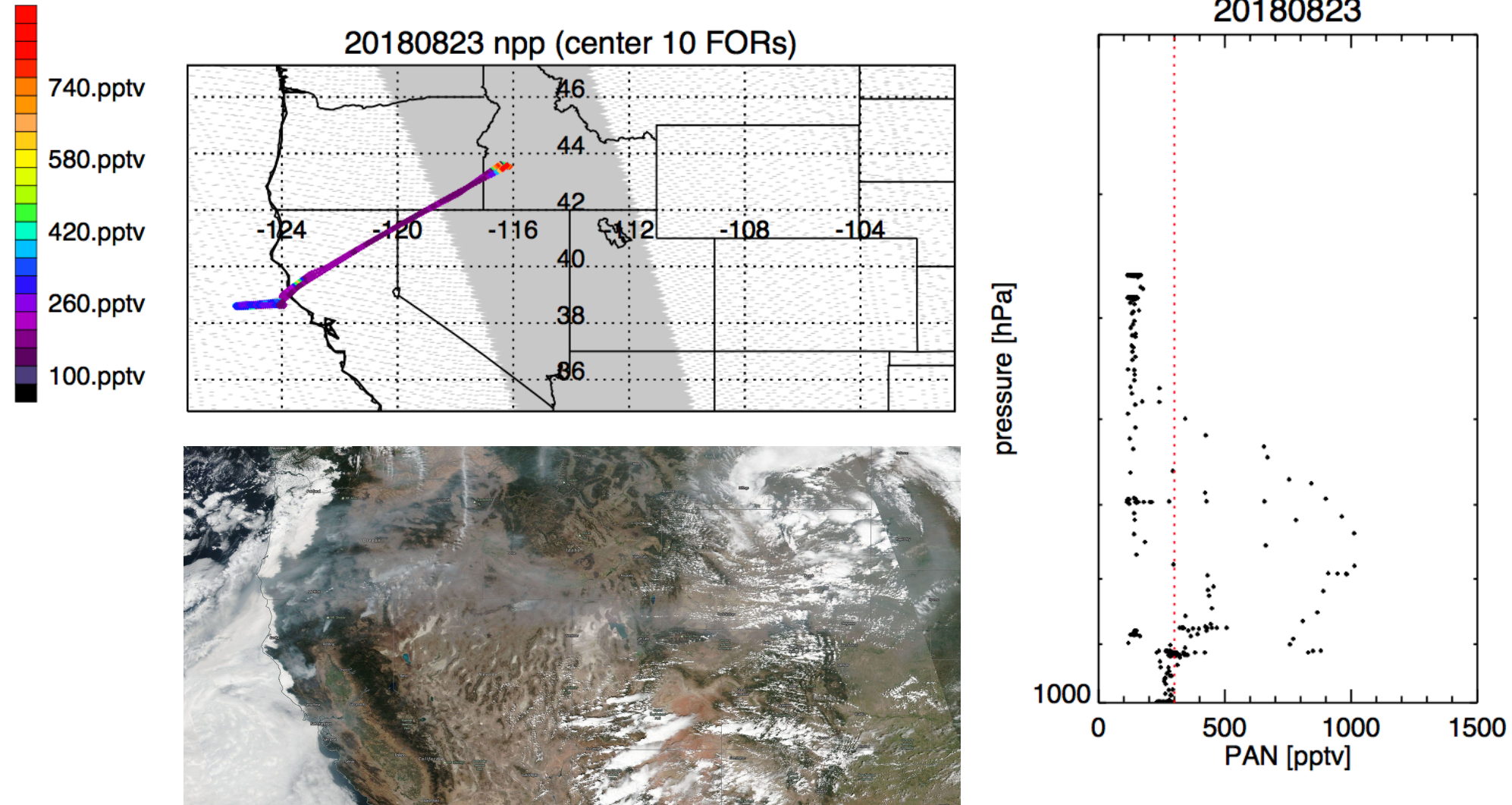
TROPOMI: Flying in constellation with S-NPP



TROPOMI aerosol index (Sentinel Hub website)



# Example day: 20180823

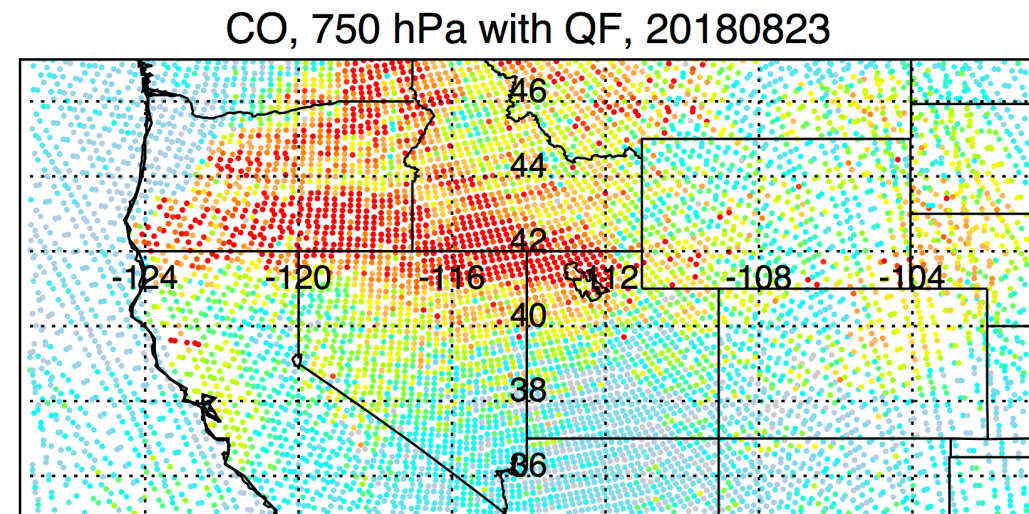
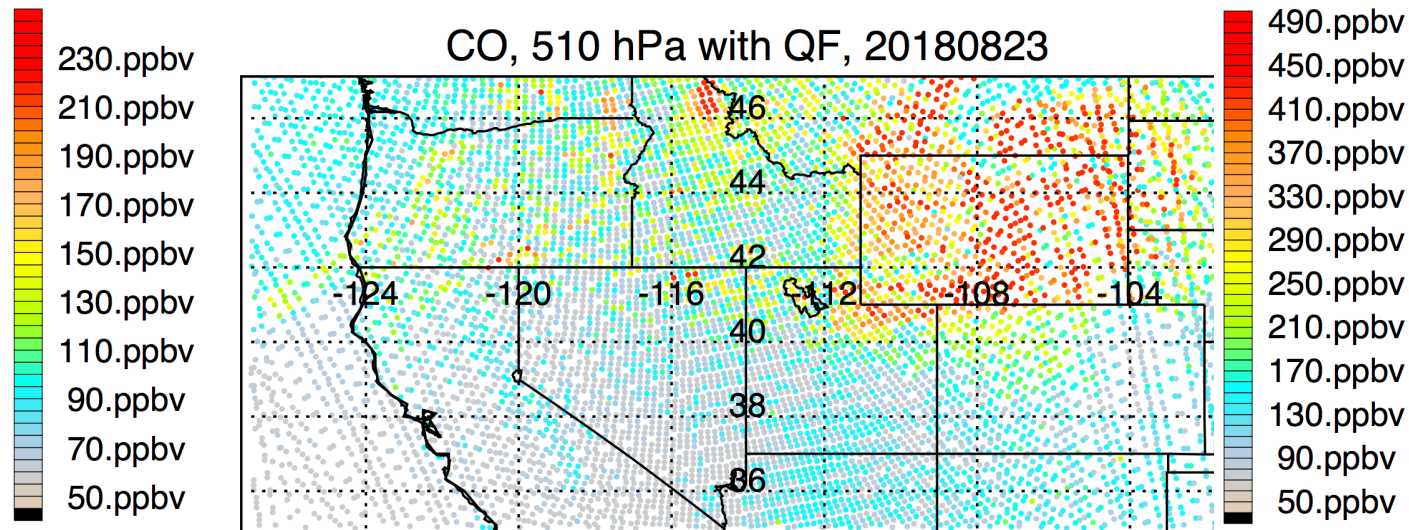
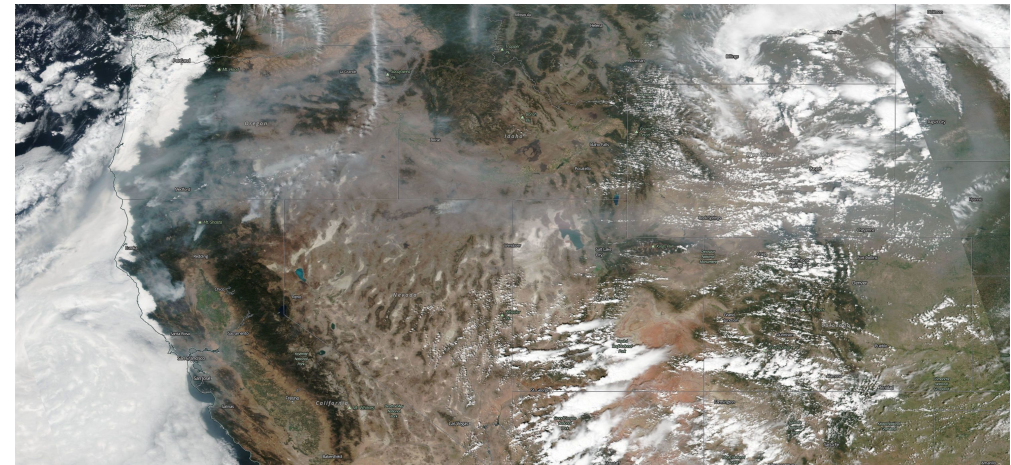
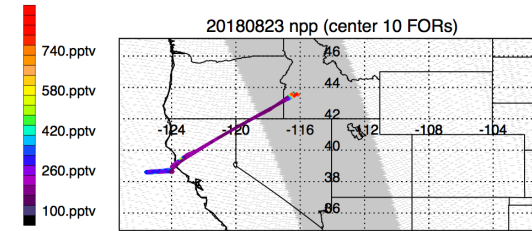
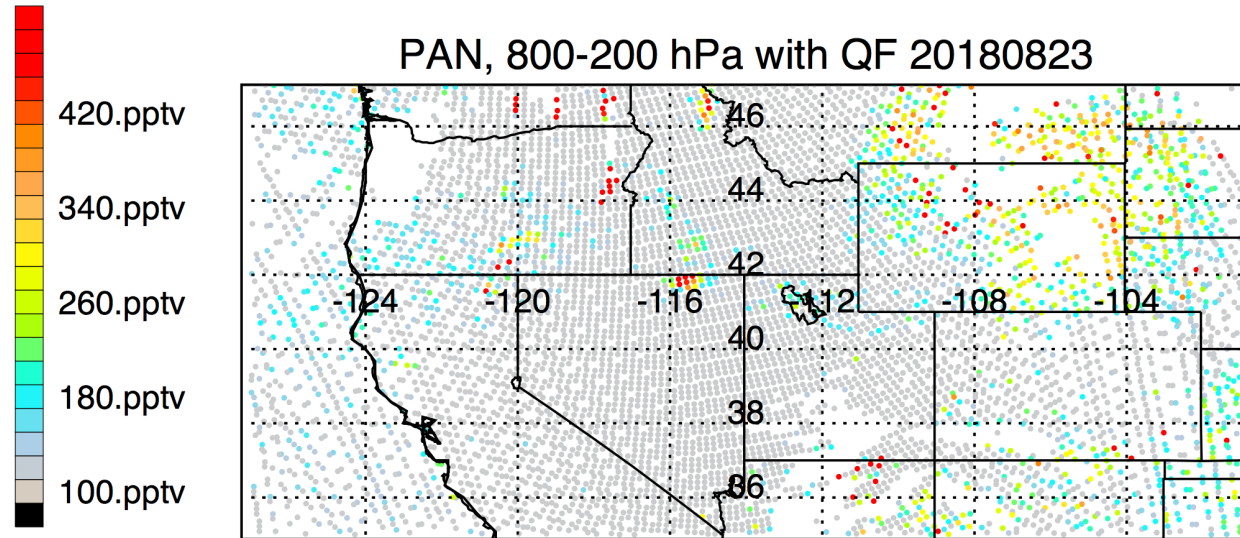


Points show aircraft  
PAN measurements

Red line: 300 pptv



# Example day: 20180823





# Summary and next steps

- **CrIS PAN retrievals for WE-CAN time period (Summer 2018)**
  - 17 days processed with MUSES
  - High PAN values in fire plumes
  - Results look promising!
- Next steps:
  - **Quantitative comparisons with WE-CAN aircraft “profiles”**
    - WE-CAN flights extend up to ~6 km (~500 hPa), limited number of intentional profiles
    - Afternoon flights provide close match in time with satellite overpasses
    - Strongly elevated PAN values in smoke plumes
  - **Quantitative comparisons with ATom-1 (Summer 2016) and ATom-2 (Spring 2017)**
    - Aircraft profile measurements extend to ~13 km
    - Mostly “background” PAN values over remote ocean, some plumes observed
    - Temporal coincidences not necessarily ideal
  - **Summer 2019: FIREChem and FIREX**

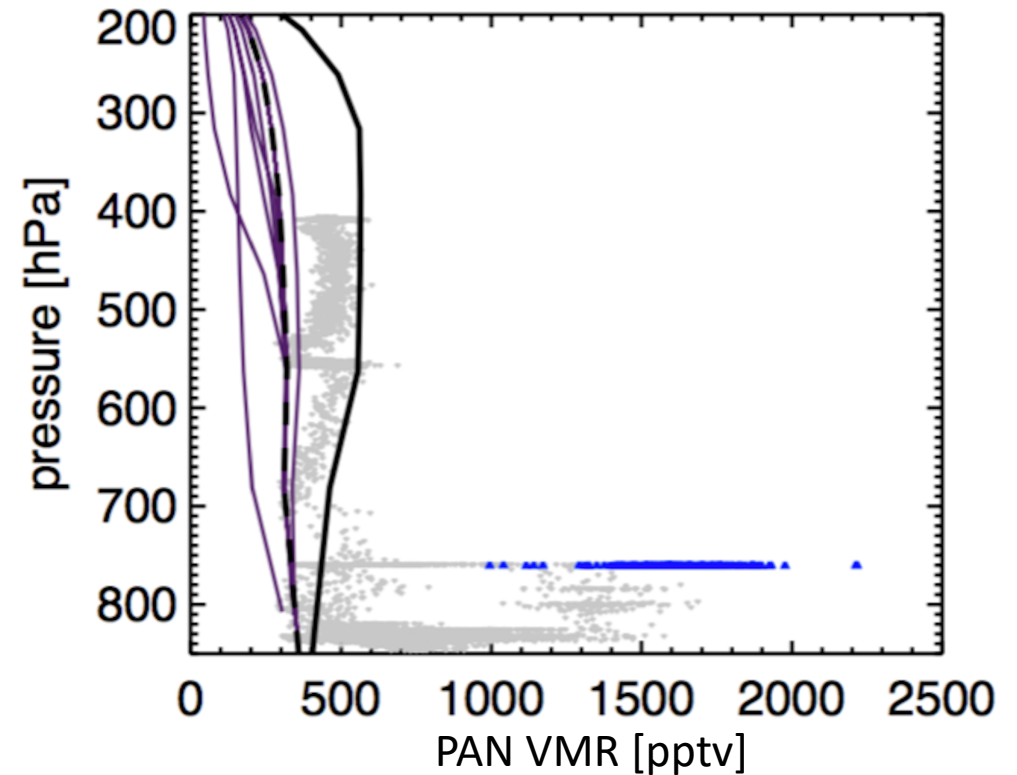
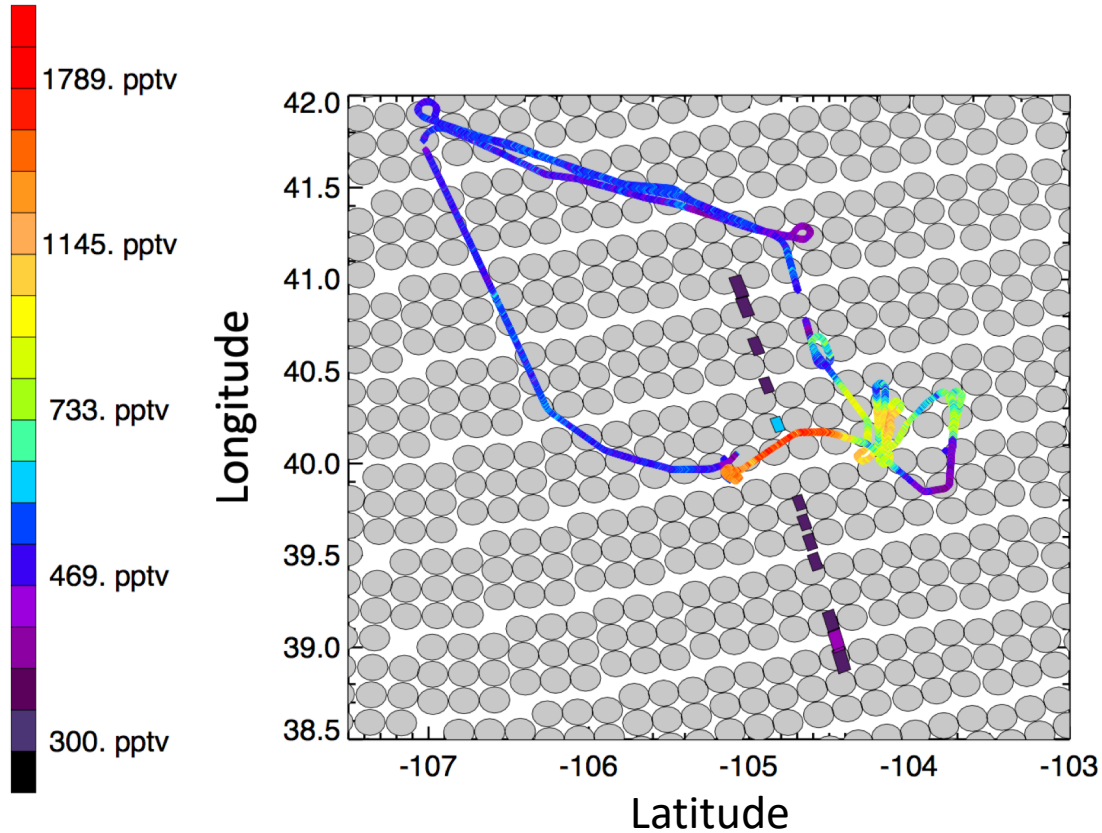
Back-up slides



# PAN shows spatial variation on small scales

Tight coincidences needed for validation

Example from FRAPPE campaign (20140729)



Modified from Fischer et al., 2018. ACP

[https://www.star.nesdis.noaa.gov/JPSS/EDRs/products\\_Soundings\\_2018.php](https://www.star.nesdis.noaa.gov/JPSS/EDRs/products_Soundings_2018.php)

**NUCAPS Carbon Monoxide at 500mb Asc NDE**

**6 Aug 2018  
Ascending**

